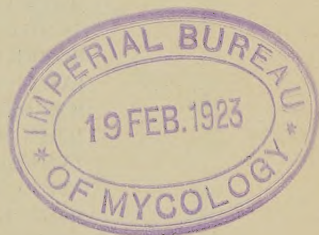

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION OF
THE COLLEGE OF AGRICULTURE
Department of Botany (Extension Work)

ONION BLIGHT



By H. H. WHETZEL



ITHACA, N. Y.
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EXPERIMENT STATION, COLLEGE OF AGRICULTURE,
CORNELL UNIVERSITY, ITHACA, N. Y., April 30, 1904.

HON. C. A. WIETING,

COMMISSIONER OF AGRICULTURE, ALBANY.

Sir.—I submit herewith a report on a very serious blight of onions. This disease has been prevalent in New York State for some years, and it seems to be spreading. The disease attacks the foliage of the onion, thereby injuring the plant to such an extent that the bulb does not reach full size, or even killing the plant. The treatment to be employed is largely preventive,—to practice rotation and to destroy all affected foliage as soon as the crop is harvested. Since onion lands are usually limited in quantity in any locality, however, it is not always possible to practice systematic rotation. Much can be accomplished by means of thorough spraying with Bordeaux mixture, but the grower must be alert and begin the work before the disease gains much headway. It is probable that the disease is not carried in the seed itself, but it may be conveyed in the dust that adheres to the seed or in the litter that accompanies it. Suspected seed may be treated with formalin.

New York leads the states in the production of onions. The Twelfth Census places the New York crop, "grown by farmers in commercial quantities," at 2,177,271 bushels. "New York led in the production of onions as in that of potatoes, producing as many bushels of onions as any other three states except Ohio, which raised over two-thirds the quantity reported for New York."

We desire to secure complete information as to the extent of the onion blight in New York State, and also to conduct further experiments aiming to control it. To these ends, we ask for correspondence from the onion growers. The present report is considered to be preliminary, designed primarily to interest onion growers and gardeners in the checking of this disease. The more technical part of the studies is a contribution to the life-history and morphology of the fungus that causes the blight. All the work has been done under the supervision of Professor G. F. Atkinson.

The following outline will enable the reader to find the particular parts of the bulletin in which he may be interested :

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Respectfully submitted,
L. H. BAILEY,
Director.



FIG. 1.—Onion field of Bonney and Ware, Batavia, N. Y., showing a bad spot of blight along the front side. Tops down, dead and rotting.



FIG. 2.—Onion field of W. A. Culver, Mecklenburg. Front side, showing onions recovered after first attack. Erect tops are the new growth. The new blighted tops are dried up and may be seen along the sides of the rows near the ground. Taken July 21, 1903.

A SERIOUS OUTBREAK OF ONION BLIGHT IN 1903.

PART I. POPULAR ACCOUNT OF THE DISEASE, WITH REMEDIES.

On July 13, 1903, Mr. W. A. Culver from near Mecklenburg, N. Y., brought to the botanical laboratory a large bunch of onions, the tops of which were badly affected with some disease. This was at once recognized as the Onion Blight or Mildew (caused by a parasitic fungus, *Peronospora Schleideniana*). Mr. Culver said that the disease was very severe, his entire field of five acres having been attacked in the course of a very few days. From the appearance at that time he had little hope of any crop at all. He was advised to spray the onions thoroughly at once with Bordeaux mixture. We made a visit to the farm of Mr. Culver to observe the disease in the field and to obtain more material for study in the laboratory.

On July 27th a letter was received from Bonney & Ware of Batavia, N. Y., saying that some disease was causing trouble in their onions. I visited their farm the next day. As anticipated, the trouble here was also found to be due to the blight, though it was not so severe as at Mr. Culver's.

It was observed in both these cases that the disease originated in one or two definite spots in the onion field. It was first recognized by the bleached appearance of the leaves, followed by their sudden collapse. The area where the disease first occurred was usually small but very striking in appearance, (Fig. 1.) The tops looked as if they had been dashed with scalding water. A close examination of the leaves in the earlier stages of the attack, showed a fine furry appearance, due to the many spore-bearing stalks of the fungus which protruded from the tissues of the host. The disease spread with startling rapidity. Often a single night or day sufficed to increase the affected area manyfold. The rapidity with which it spread, together with the apparent completeness of its destruction, entirely dismayed the average grower. The very evident necessity of attacking it at once was met by the lack of knowledge of what to do, or the impossibility of spraying large areas quickly enough or with sufficient thoroughness to check the disease.

All these facts seemed to indicate that the trouble would be very general and destructive to onions throughout the state. It was, therefore, decided that the entire time during a part of the season should be devoted to an investigation of this disease. It was hoped by this means to determine: 1st, the general distribution and prevalence of the disease throughout the state; 2d, the relation of location, soil, drainage, weather, etc., to the life of the fungus; 3d, its means of dissemination and perpetuation; and 4th, methods of successfully combating it. With these objects in view, onion growers in the different sections of

Western New York were visited and their fields inspected. It is true that there were many large growers not visited, but reports and rumors from many of these indicated that most of them were troubled more or less by the disease. Of the fields visited, only one or two appeared to be entirely free from the blight. It is very likely that even these fields were effected to some extent later in the season. The fact that the disease usually attacks the tops about the time that the bottoms are maturing, has led many growers to believe that this early dying down of the tops is due to the natural ripening of the onions. For this reason it was hard during the later visits to convince the growers that their onions had the disease.

While the distribution of the disease throughout the territory visited was general, there was great difference in its severity in different places. In the field of W. A. Culver, the disease appeared early. This field was well drained upland. The onions stood thick on the ground and Mr. Culver estimated, before the blight attacked them, a yield of 5,000 bushels for the five acres. A week later, on my first visit to the place, although the onions had much recovered, he told me that he did not then expect half that amount. Almost every onion had been attacked. Careful searching up and down the rows revealed only two or three apparently healthy onions. The blight again visited this field after the onions had largely recovered from the first attack. The second attack was worse than the first and put a stop to all further growth of the onions. The field had been planted to onions the previous year (1902) and they had been blighted. The disease had attacked them nearly a month later than during the present year and after the bottoms were well formed, so that the damage was comparatively slight. The larger part of the blighted tops of the crop of 1902 had been left on the field and this accounts to some extent, as will be shown later, for the severity of the disease during the present year.

Bonney & Ware of Batavia had but three acres of onions. This was on muck land that had been cleared the year before and had produced a single crop of celery. Onions had never been grown on or near this land. However, blight was found among them. The onions stood thick. The tops were strong and healthy. The land was low and conditions seemed favorable to the parasite, yet the blight appeared only in a few spots along one side of the field. These spots were thoroughly sprayed at once. The disease did not spread to any great extent and little damage was done.

On the farm of W. B. Howard near Fulton, Oswego county, the story of the disease was much the same as that at Mr. Culver's. Here the onions were on muck, low and not well drained. The land was so level that it was impossible to get sufficient fall for drainage. The onions were not so thick on the ground as at the other places mentioned. The blight here came nearly a month later than at Mr. Culver's. The onions too, had been sown later and were scarcely more than one-fourth grown when first blighted. In the opinion of Professor Rowlee, who was spending his summer on this farm, the bulbs

never grew after the first attack of the blight, so that the crop was reduced at least three-fourths. The disease was fully as severe on the farm of Peck Brothers of Fulton and on that of Powell & Smith of Syracuse. In the case of Powell & Smith, however, only parts of the field were affected and the degrees of severity differed considerably even in the affected parts. In some spots the destruction was quite complete, while in others the blight did apparently little damage.

The onion fields about Canastota are all on low-lying muck lands for the most part well drained and long under cultivation. A large number of fields were visited, the largest belonging to any one party being perhaps that of Mr. Fred Twogood, about forty acres of whose farm was in onions. The blight throughout this district, while general, few fields being entirely free from it, was not so severe as in other sections of the State. A few small patches showed it in its worse stages, the tops practically all dead or dying. The lateness of the season at which the blight became prevalent in this section was very favorable to the growers. The bottoms were well formed and the growers were inclined to regard the dying down of the tops as the natural maturing of the onions.

On the whole, the disease was very severe throughout the districts visited and loss due to reduction of the size of the bulbs (to be discussed later) was considerable. Many farmers declared that the growing of other crops must be undertaken on these lands unless some means of checking the ravages of the disease is discovered.

THE DISEASE IN THE STATE IN PREVIOUS YEARS.

Inquiries brought out the fact that the disease was not new to the onion growers of the State. Several remembered some previous year in which the same disease had been quite as destructive as during the present season. Some of the more observant declared that it occurred every year more or less, but usually so late in the season as to do little apparent damage. This seemed to be borne out by the fact that the early dying of the tops had come by many to be regarded as the normal ripening of the onions. The fact that the disease was most general and severe on those lands previously devoted to onion culture, seemed also to support these observations. Mr. Culver, especially, had observed it in his field during the season of 1902, and had made some effort to eradicate it by pulling the tops in the spots first affected and burying them. In general the information regarding its occurrence in the State previous to 1903, as obtained from growers, is rather indefinite. None of them seemed to be acquainted with the true nature of the disease and though it was often referred to as smut, blight, "wet weather," etc., it is evident from their descriptions that it was the blight that had caused the trouble. Professor William R. Dudley, formerly of the Cornell University Agricultural Experiment Station, reported it as having been common in the vicinity of Ithaca

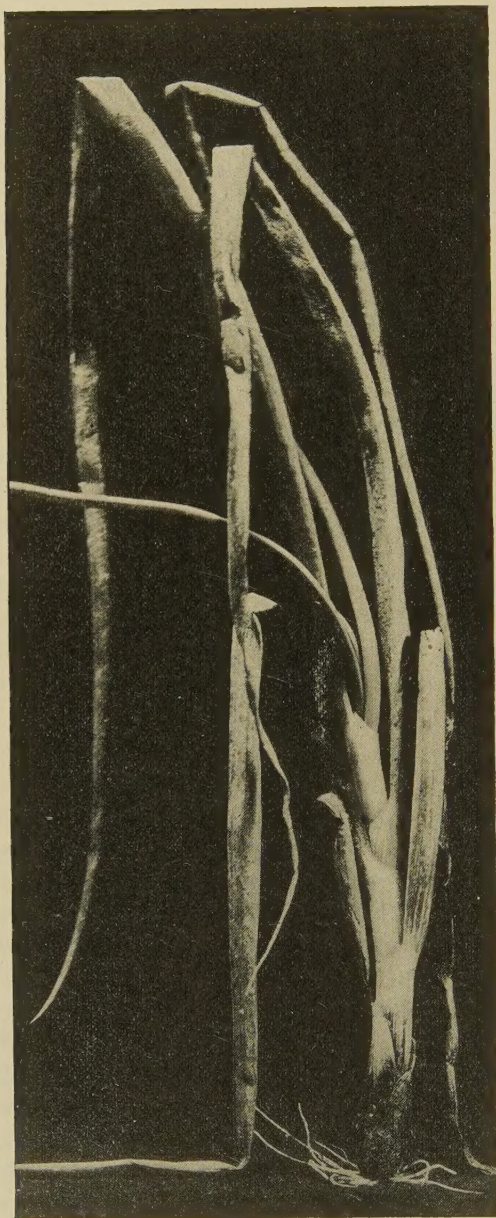


FIG. 3.—Onion blight. Worst stage. Fungus at its best. Two new inner leaves just appearing, not yet affected.

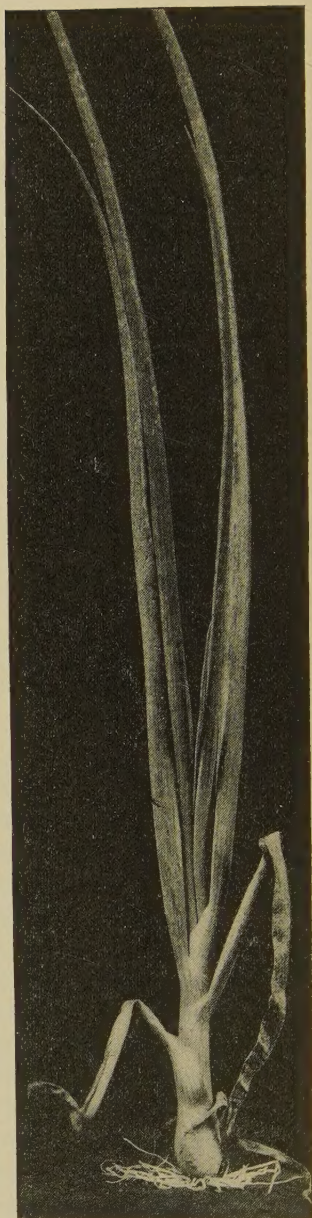


FIG. 4.—Onion top recovered after first attack. Lowest leaves dead. New growth abundant, erect.

during the season of 1888. It would thus appear that the blight has occurred very generally during the previous seasons and with considerable severity in some cases. The fact that it does not directly affect the bulbs as does smut or maggots, has caused most growers to attribute it to some natural or climatic condition, and so they have not regarded it as serious. Only when it came early in the season and the damage was severe and marked did growers regard it as a disease.

HOW THE DISEASE AFFECTS THE ONION.

How to recognize the disease upon its first appearance is one of the important things for the grower. After the fungus has spread over the entire field and the onion tops are dead or dying, it is no difficult matter for anyone to see that something is wrong. The rapidity with which the disease spreads demands that there be some sign by which we may discover the disease in its earliest stages and so be better enabled to cope with it. Unless

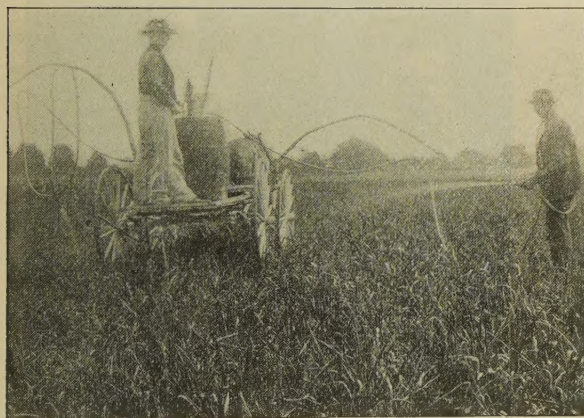


FIG. 5.—Spraying with Bordeaux mixture for onion blight on the farm of J. Howard, near Fulton, N. Y. A little nozzle attached to the end of a 25 ft. hose. Two lengths of hose to the same pump. A strip 30 rows wide could be sprayed at one time. Swinging the hose from the ends of the poles which worked in a socket, saved the cost of two men. This apparatus was planned by Prof. W. W. Rowlee.

the crop of the previous year had been badly infested the fungus first appears on a few onions in one or more parts of the field. The first "muggy" weather of July or late June should be the signal for a general looking over of the fields to discover any infected plants. The examination is best made in the early morning while the dew is still on the onions. A diseased leaf is then easily discernable at a considerable distance. Parts of it will appear of a peculiar violet tint, due to the furry covering of the fruiting parts of the fungus. These will stand out very abundantly and plainly on account of the moisture. Later in the day the parts are more or less collapsed by the drying of sun and wind, and the diseased leaf is more difficult to see. Aside from this peculiar furry violet appearance, the affected leaf is at first like the healthy ones about it. By the second day it has begun to lose its bright color, being paler or even yellowish in spots, where the disease first started. It will now be mouldy or furry throughout most of its length and by the third or fourth day collapsed and broken over. The fungus usually appears first on one side of the leaf about midway between its tip and base, from which it spreads rapidly through the entire leaf. Unless

the weather is especially favorable the disease will not spread over the field rapidly, but areas several feet in extent will first be evident, here and there through the patch about the places which were first attacked. Fig. 1 shows such a spot several days after infection had first occurred. The tops have gone down badly, largely from the weakening effects of the fungus. Fig. 3 shows an onion at the acute stage, taken from such a spot. After several days the affected onions begin slowly to recover. New leaves appear. These replace the affected ones which are drying up. If weather conditions are favorable to the onions this new growth is rapid and often in a week the field appears almost as thrifty as ever (Fig. 2). The affected leaves have quite dried up and disappeared while the new growth is erect and green. (Fig. 4.) The ability of onions to recover from a severe attack was shown to an extraordinary degree in the field of Mr. Culver. On July 13th he brought specimens to the laboratory in the condition of the one shown in Fig. 3. He said that the tops were all down and that they looked as if they had been drenched in boiling water. The disease was then at its worst. A week later,

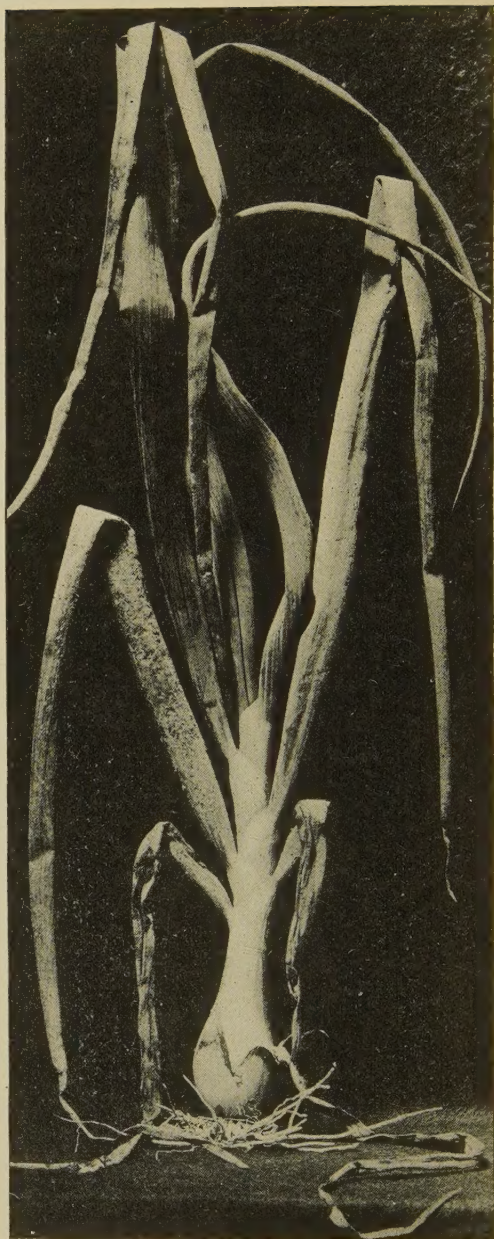


FIG. 6.—Onion blight. A second attack. Lower dried up leaves killed by first attack. New growth which is strong and vigorous now affected. Leaves becoming weak, due to collapse of tissues.

July 21st, I visited the same field. I was surprised to find the onions erect and green with little traces of the apparent devastation of the previous week. A closer inspection, however, disclosed the fringe of dried leaves on either side of the row along the ground and here and there a few green leaves showing traces of the fungus. The onion, shown in Fig. 4 was gathered at that time and is typical. Fig. 2 shows a part of Mr. Culver's field at the time of the first visit, one week after the first attack had been at its worst. Scarcely any trace of the disease can be seen in the photograph. Fig. 5 shows a badly affected field, the tops are nearly all affected and breaking over. The rainy weather during which the disease was first so destructive in Mr. Culver's field was succeeded by bright warm days with considerable wind, just the best growing weather for onions and the most unfavorable to the disease. It must always be remembered that weather conditions are a great factor in the recovery of the onions. The blight, of course, never entirely disappeared from the field and with the return of wet weather about August first, the fungus again spread over the entire field, attacking and destroying the new growth of leaves. On the second visit, August 11th, I found the onions in very bad condition (Fig. 6). The tops were down and the entire field had a sickly yellow color. The onions never recovered from this second attack.

The story of Mr. Culver's field is to a large degree the story of every blighted onion field. If the first attack comes late in the season the onions will likely never recover at all. If weather conditions remain favorable to the fungus the new growths are affected as fast as they mature. It was discovered that young onions and rapidly growing leaves, however, were not so liable to infection. Leaves which had reached maturity or those weakened by breaking or by the ravages of thrips seemed most easily infected by the fungus. This accounts for the rather late appearance of the fungus. Apparently onions are the most susceptible about the time the bottoms begin to form, after the leaves are for the most part done growing and are devoting their energies to the making of the bulb. Our observations were for the most part on onions grown from the seed. Some seed onions were seen but no blight was observed on them. Thaxter, in 1890, reported blight as occurring only on seed onions, while onions next to them, grown for market, were not affected. Fifty per cent of the seed in this case did not mature.

As this disease does not disfigure the bulbs or destroy them as smut or maggots do, growers are not likely to consider it as a very serious trouble. Besides, the disease does not often become serious until the onions have attained considerable bottoms, and so the grower is deceived as to the amount of injury done. It is, of course, the growth of the leaves that is directly affected.* The nutrition which should have gone to the growing part of the

* The conidiophores choke the stomates and prevent the circulation of the air. The haustoria or suckers which penetrate the leaf cells suck out the sap and nutrition of the cell. The cells are thus very much weakened and finally killed. They lose their plumpness and collapse, causing the leaf to break over and shrivel up.

leaf and bulb is largely used up by the parasite. The leaf is the part that takes the plant-food that is brought up from the soil in solution in the sap, and the carbon dioxid from the air and manufactures the substances of which the bulb is composed. It is the important part of the onion during the growing period. No grower would expect bulbs to form on plants from which the leaves were removed as fast as they were formed. Neither would he expect onions to attain the proper size if the tops were cut away when the bottoms were half formed. This very thing is what practically takes place when onions are severely blighted. The entire working part of the onion is disturbed and destroyed. Growth of the bulb must of necessity stop. A new growth is then necessary and the energy of the plant is directed to that, while growth of the bulb ceases. As have already shown, this new growth has scarcely attained sufficient size and maturity to take up the bulb building work again when it is attacked by a second epidemic of the blight. Even if the most favorable conditions prevail, the time lost during the acute stage and the recovery means a considerable reduction in the amount of bulb produced. It is the reduction in the size of the bulbs that we wish to emphasize as the chief effect of the blight. Usually little or no increase in the size of the bulb takes place after a severe attack of the fungus. If the attack comes after the bulbs are half formed this means the loss of one-half the crop. Conservative growers this year estimated that their yield per acre was reduced one-fourth to one-half by the disease. This meant a loss of many hundreds and even thousands of bushels. Undoubtedly this disease often reduces very materially the onion yield in the State of New York. Growers have come to regard 400-500 bushels per acre a good yield, yet every grower knows that 700-1000 bushels is not an uncommon yield under favorable conditions. This difference between the ordinary yield and that which is possible I believe to be due to a considerable extent to the blight. It certainly was so during the past season. Maggots and thrips do their share. On muck lands light stands often occur as the result of the blowing out of the seed during the dry weather at planting time. However, in those cases where the stand is strong and even much larger yields would be realized if the blight could be controlled.

There is another disorder or appearance of the onion that sometimes alarms the grower, but which is really only the work of a secondary fungus that thrives on plants that have already been weakened by the blight. This secondary fungus is a kind of mold or mildew, giving the leaves a black or sooty appearance. It is described more fully in Part II (page 149).

TREATMENT.

The question of how to control this disease is the all important one to the grower. Two ways present themselves : first, by checking the disease after it has once started in the onions ; and second, by preventing it from getting a start. As is usual the former is the more difficult of the two. We have seen

that the fungus lives within the leaf tissues of the onion sending forth only the conidia bearing stalks. It is very evident then that when once the mycelium is started in a leaf, *i. e.*, when once the leaf is infected, poisons applied to the surface have no effect on the fungus within. So far as the infected leaf is concerned it is doomed. If the disease has spread over a large part of the field, the vast majority of the leaves will have been affected. We cannot hope to save those leaves. They will certainly be killed. Evidently then the only way to handle the blight is to prevent the infection of the onion leaf by the fungus. Preventative measures are numerous and effective, depending upon the time at, and the conditions under which they are applied.

Killing the fungus.—What is to be done when once the disease has spread over the entire field? If weather conditions are at all favorable a second growth of leaves will be produced. Should the attack come early in the season, say July first, this new crop of leaves could do much toward producing a normal yield of bulbs. It is desirable in such a case to protect this new growth if possible. Experiments in spraying by growers throughout the State during the past season did not seem to be very successful in accomplishing this. I believe, however, that this is possible, and wish to point out that in no case did the grower spray more than once. In most cases where spraying was done, the spray was applied thoroughly and satisfactorily. Standard Bordeaux mixture was used. A second application was never made although the necessity of it was urged if good results were to be obtained. In many cases the disease appeared to have been checked by this single application, but with the return of damp muggy days, the spores produced anew from the mycelium within the sprayed leaves, spread to the new unsprayed growth and a repetition of the former devastation occurred. If this new growth had been kept thoroughly sprayed, the spores falling upon the poisoned surface would have perished at once and infection have been rare. In badly infected fields spraying can only be expected to protect the new growth and uninfected leaves. Where the blight is only present in spots, a thorough spraying of these spots to kill all spores in order to prevent infection of uninfected areas is to be strongly recommended. A single application, as already pointed out, will not be sufficient. The number of applications and the time at which they are to be made will depend upon weather conditions almost entirely. If there are clear sunny days and plenty of breeze and no dew at night, the disease will not spread and a second application will not be necessary. As such conditions will almost never continue for any length of time, it will be necessary to spray every few days. If damp cloudy weather prevails spraying should be done at least every ten days; oftener is advisable. The new growth should always be sprayed as soon as it has attained considerable size no matter what the weather may be. If the crop is attacked, *spray with Bordeaux mixture: watch the plants closely, and spray again if the disease is not checked.*

Preventing the disease.—So far methods of attacking the disease once it

has appeared in the field have been discussed. Since the blight fungus is so generally distributed throughout the State and nearly every grower may be expected to be troubled with it, measures for preventing or controlling it should be begun early in the season. This probably will be found to be most successfully accomplished by *systematic spraying, beginning the latter part of June or the first of July, and continuing throughout the season.* This has been used very successfully by onion growers in Europe. Mr. Beech, of the Geneva Station, reported this as successfully used by onion growers in this State some years ago.

Two things are always to be insisted upon in applying the spray: 1st, thoroughness; every side of the leaf must be covered. 2d, force; the mixture must be applied with sufficient force to make it stick to the smooth surface of the onion leaves. A nozzle that gives a fine spray should be used. One of the most successful spraying machines that I have seen is the one shown in Fig. 5. Mr. Culver used a machine in principle very similar to this. The Bordeaux used was mixed in the proportion of four pounds of lime and six pounds of blue vitriol (copper sulfate) to a barrel of water. It was found that in some cases this seemed to burn the leaves. A larger proportion of lime would very likely obviate this trouble. A reduction of the strength of the solution has also been recommended.

We have seen that *location and drainage have much to do with controlling the blight.* Properly drained lands are less liable to the disease than wet ones. All barriers, such as, tall weeds along ditches or the sides of the field should be removed so as to admit the air freely to the growing onions, thus assuring the rapid evaporation of dews and rains. Lands for onion fields should be chosen in places as much exposed as possible. Swamps surrounded by high hills are especially unfavorable.

We have now considered the means of attacking the fungus in the summer stage. There remains to be considered the winter stage. Since the summer stage which is the destructive one, perishes with the approach of winter, it is evident that if the resting spores by which the parasite manages to pass the winter could be destroyed the disease could not reappear the following season. These spores, as we shall see, pass the winter in the dead leaves of the onion. These leaves are usually left on the field. Even where they are most carefully raked up and burned large numbers of oospores must still remain in small broken pieces of leaves which cannot be removed. *The raking and burning of the tops is to be strongly recommended, as in this way a large part of the resting spores are destroyed. The practice of throwing tops and decaying bulbs back on the field or on manure piles cannot be too strongly condemned.* It has been suggested that the burning of a layer of straw scattered over the field just after the removal of the onions would kill these spores. No doubt it would materially aid in reducing their number. To my mind the most feasible method offered, however, is the sterilizing of the upper layer of the soil with steam and

hot water by means of an especially devised apparatus. This is said to have been successfully used in destroying weed seed, insects and fungi. The most promising machine for this purpose yet put upon the market is one invented and manufactured by Mr. Luke Kavanaugh, Waterford, N. Y. It would be well if the efficiency of this machine in destroying fungus spores could be tested.

Since it is believed that these resting spores retain their vitality for two or three years it is advisable, where blight has been very severe, to *try rotation of crops*.

The necessity of great care to prevent infection, by these spores, of lands free from blight and those planted to onions for the first time cannot be too strongly emphasized. I think it is generally by the resting spores alone that a field becomes infected, unless there are infected fields immediately adjoining it. The short period of vitality of the summer spores and their susceptibility to the drying effects of the wind seems to show that they never convey the disease to any great distance.

In the case of many fungous diseases certain immune or resistant varieties of the host plant occur or have been developed. For example, certain varieties of the apple are entirely immune to the apple rust, so destructive to other varieties. Shipley observed that the red varieties of onions were apparently least affected by the blight. My observations seem to confirm this. Although the red varieties seemed always to be affected in fields where white onions were diseased, still they did not seem to suffer to such an extent. It is possible that by careful selection a variety of onions might be obtained that would be immune to the disease.

Anything that tends to weaken the onions in any way, as too much moisture, shelter or transplanting invites the disease and should be guarded against. *There is little danger of introducing the disease through the seed if the seed is perfectly clean of bits of leaves or stems which might harbor the spores. As a precautionary measure, seed might be treated with formalin. Soak from one-half to one hour in a .5 per cent ($\frac{1}{2}$ of one per cent) solution of formalin before planting.* This will prevent the introduction of onion smut also.

PART II. A MORE TECHNICAL ACCOUNT OF THE ONION BLIGHT, AND OTHER DISEASES.

THE FUNGUS,—ITS NAME AND LIFE HISTORY.

The fungus which living as a parasite in the tissues of the onion leaf causes this disease was first described and named by Berkley (1841). He called it *Botrytis destructor*. Unger (1847) described it as *Peronospora schleideni*. Shortly after Berkley had first described and figured the parasite, Schleiden (1849) described it referring it to the species *Botrytis parasitica*. In Berkley's Outlines of British Fungology, 1860, it is listed as *P. destructor* Caspary. What Berkley's authority for the use of that name is, I am as yet unable to determine. Later De Bary (1863), while revising the genus changed the name to *P. schleideniana*. This name has perhaps been the most generally used, and especially in recent literature. It is, therefore, retained in this paper.

P. schleideniana, like most species of the downy mildews, has two quite distinct stages in its life history: 1st, the vegetative or conidial stage by means of which the fungus disseminates itself and during which it is most destructive to its host. This stage flourishes only under the most favorable conditions: 2d, the sexual or resting stage which appears at, or toward the close of the conidial stage. It is by means of this stage that the parasite is carried over long periods of unfavorable conditions, viz., winter, drought, lack of food supply, etc. We will now consider these two stages in detail. This will help us to more intelligently discuss the various conditions of weather, location, etc., affecting the fungus at different times in its life and so enable us to combat it with some hope of success.

The conidial stage.—If a badly affected onion leaf is carefully examined with the naked eye it will be seen to be covered in places with a dense mouldy growth, which from its peculiar violet tinge is often discernable at a considerable distance. Examination of this with a hand lens shows it to be due to innumerable erect branched threads, which appear not unlike so many tiny trees standing out from the leaf. These stalks are themselves colorless, but on the ends of many of the branches will be seen little egg-shaped bodies, the conidia or spores. These bodies are the "fruits" of the fungus, the spores by which it reproduces itself. One of these conidiophores, bearing conidia and much enlarged is shown in Fig. 7. Further examination shows that the conidiophore comes from within the tissues of the leaf.

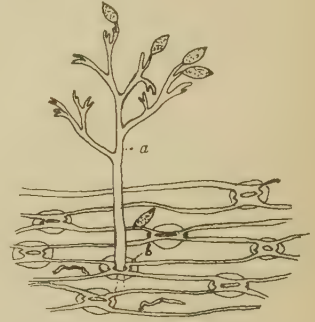


FIG. 7.—A part of the epidermis of an onion leaf with conidiophore (a) protruding from the stomate (b).

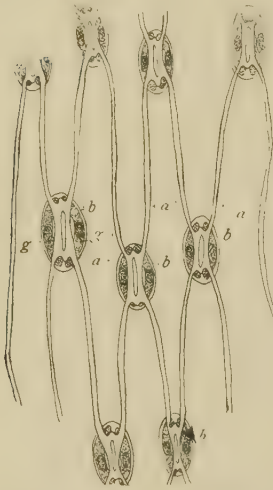


FIG. 8. A part of the epidermis of a healthy leaf, much enlarged. (a) The long cells. b, b, The stomates. g, g, guard cells of the stomates.

In order to understand how the parasite lives within the tissues of the host, it is necessary to see what the structure of the onion leaf is. With the thumb-nail it is easy to scrape or peel a thin transparent layer from the surface of the leaf. This is the skin or epidermis (Fig. 8) and is composed of a single layer of long cells between the ends of which are peculiar round structures with a slit or opening through them. (Fig. 8b, b.) These are the stomates or breathing pores of the leaf. It is through these that the air passes in and out of the leaf and through these water is given off in the form of vapor. They are very important organs of the leaf, for through them alone is there connection between the inner tissues and the outside air. Two large guard cells (Fig. 8g, g,) one on either side, control the size of the slit according to the condition of moisture, etc.

If we split a leaf lengthwise and take a very thin slice from one of the edges, it will appear in the microscope as in Fig. 9. The cells of the epidermis with the guard cells cut through edge-wise form the first or outer layer (a). Just beneath this are rather long sack-shaped cells with their long axes at right angles to the epidermis to which they are fastened. They are arranged very loosely, often not touching each other at all (Fig. 9b). These are the palisade cells. Their inner ends are fastened to loosely arranged cells of the same sort, but which are more or less globose and in one or two layers, (Fig. 9c). These three layers of loosely arranged cells contain most of the chlorophyll of the leaf and are known collectively as the mesophyll cells. These are the

cells in which the food of the plant is manufactured from the raw materials brought to them. Their loose arrangement leaves many intercellular spaces. These are connected with the openings of the stomates, (Fig. 9d). This allows free circulation of air among the mesophyll cells, which is quite necessary in some of the work that the leaves do. Next to the inner mesophyll cells are several layers of large oblong cells, which in section look not unlike brick work, (Fig. 9e). Their long axes are parallel with the long axis of the leaf. These cells contain but little chlorophyll. Their chief function is to conduct liquids back and forth.

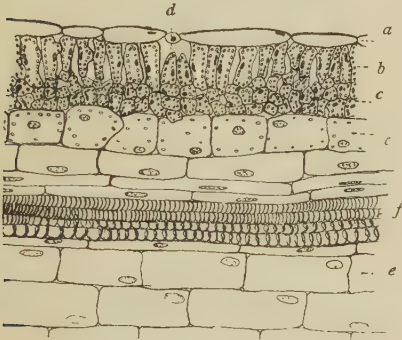


FIG. 9.—Longitudinal section of a healthy onion leaf. (a) Epidermis; (b) palisade cells; (c) lower layers of the mesophyll cells; (d) air chamber beneath the stomate; (e) large conductive cells; (f) fibro-vascular bundle.

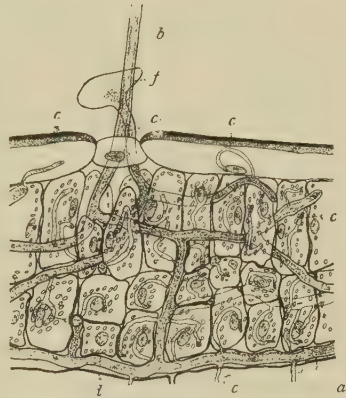


FIG. 10.—Longitudinal section through a portion of a diseased leaf; (a) mycelial threads of the parasite; (b) a conidiophore, the continuation of one of the internal mycelial threads; (c, c, c) haustoria; (d) nucleus of the host cell; (e) germ tube of the conidium; (f).

If a similar section to the one already described is made through a diseased leaf (Fig. 10) many fine, almost colorless threads (a) will be seen to wind their way through the intercellular spaces among the mesophyll cells, branching frequently. They even push through between the closely packed conductive cells (Fig. 11). These threads are the mycelium of the fungus. By following one for some distance it will at length be seen to

pass out through one of the stomates (Fig. 10b), giving rise to one of the conidiophores as already described. Different stages in the formation of these conidiophores are shown in Fig. 12. At first they are but the ends of these mycelial threads which, as they near a stomate, (Fig. 13) turn and grow out through it. Soon they branch to form the mature conidiophores (Fig. 14).

The mycelium, in order to grow and spread through the leaf, must obtain nutriment in some way from the host. As the threads wind about among the cells they send



FIG. 11.—Mycelial threads between the large conductive cells of the leaf; (a) the mycelial thread; (b, b) branched or coiled haustoria; (c) branched haustorium wrapped about the nucleus.

off smaller short branches that penetrate the walls of the host cells (Fig. 10c) and (Fig. 11b). These usually branch once or twice within the cell. These suckers or haustoria, as they are called, absorb the sap and nutriment of the cells and conduct it to the growing mycelium. In badly affected leaves every one of the mesophyll and conductive cells has one or more of these haustoria in it (Figs. 10 and 11), sucking up the food substances which the

cells need for their own growth and activities. Every cell (Fig. 10) of the leaf has a small body within it, denser than its other contents. This is called the nucleus (d) and is the most vital part of the cell. Often the ends of these haustoria wrap themselves closely about the nucleus (Fig. 11c).

The conidia or spores, as shown in Fig. 12, are formed at the end of the branches of the conidiophore. They begin as little swellings at the tips of these branches (Fig. 12a). These gradually enlarge until the mature spore is formed, which is then separated from the branch by a thin wall. These conidia are egg shaped (Fig. 14b) and quite sharply pointed at one end. They are about $45\text{--}58 \times 20\text{--}25\mu^*$ in size. The walls of the conidia are of a pale violet color and very thin. The wall encloses a mass of protoplasm, the living part of the spore. These conidia are very light and very loosely attached to the branches when ripe. They are blown about to healthy leaves of neighboring plants by the slightest breeze. If they chance to fall into any bit of rain or dew which clings to the leaves they germinate at once, sending out a small thread-like tube from one side (Fig. 14c), which seeks a stomate (Fig. 14d).

This tube grows through the opening of the stomate into the inter-cellular spaces of the leaf and gives rise to mycelial threads (Fig. 10e) whose haustoria, (Fig. 10c, c) entering the cells of the host, supply the young mycelium with food. It grows rapidly, and spreading through the leaf, soon sends forth conidiophores bearing conidia. These are scattered



FIG. 12.—Different stages in the development of the conidiophore and conidia. (a) tip of a branch swelling to form a conidium; (b) conidiophore just emerging from a stomate; (c) conidiophore just beginning to branch; (d) conidia nearing maturity; (e) mature conidium.

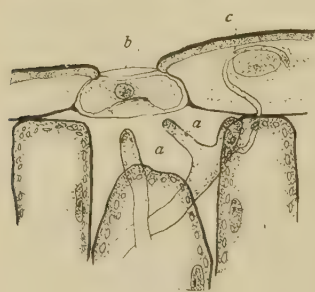


FIG. 13.—Young conidiophores. (a, a) turning toward the stomate; (b); (c) haustorium wrapped about the nucleus of the epidermal cell.

to other leaves and the process of infection and growth is repeated indefinitely. The entire process requires but a few hours or a day at most, and hence the rapid spread of the disease. The conidia are short-lived and lose their germinating power in a very short time.

Sexual stage.—A microscopical examination of a badly affected leaf will often show numerous globose bodies scattered through the tissues. These are the sexual or resting spores (Fig. 15). They are rather large globose bodies about 30μ in diameter. They are always formed within the tissues of the host while the conidia as already shown are formed without. Some of the short branches of the mycelium swell at the end and as this swelling enlarges it is filled with a dense mass of protoplasm, the living substance of the mycelial thread (Fig. 16). The oogonium, as this enlargement is now called, has a single thin wall, and its protoplasm is granular and almost colorless. About this time another mycelial thread grows up along side the oogonium. The end of this thread swells slightly but in a rather irregular form and remains much smaller than the oogonium (Fig. 17b). The contents of this swollen tip also becomes dense and granular. This is the antheridium and contains the fertilizing sperm.

* μ equals 1-2500 of an inch.

The antheridium now applies itself closely to the surface of the oogonium. A cross wall is formed at the base of both the oogonium and antheridium cutting off their contents from the rest of the thread (Fig. 17c). The contents of both the organs now contract

and become denser, leaving a clear colorless region between the wall and the central mass. This central mass of the oogonium is the *oosphere* or egg. A small tube grows out from the antheridium, penetrates the wall of the oogonium and extends into the egg (Fig. 17d). The contents of the antheridium pass through this tube and unite with the contents of the egg, which is now said to be fertilized and is called an *oospore* or fertile egg. Changes now begin to take place in the oospore. It surrounds itself with a thick wall, which when the oospore is ripe, is of a pale brown color. The wall is smooth, the contents granular and usually with several large oil drops. The oospore (Fig. 15b) formed in this rather complicated manner, is of the utmost importance to the parasite, for upon this spore the fungus depends to be carried over until the next season. The wall of the oospore now thickens and the protoplasm becomes dense and oily. It is thus enabled to withstand great extremes of cold, heat and moisture, conditions under which the conidia would quickly perish.

These oospores are formed in great numbers, as an examination of a dead and dried up leaf will show. The dry leaves are easily broken from the onion in gathering and lie on the ground during winter, decaying more or less. Onions are usually planted again on the

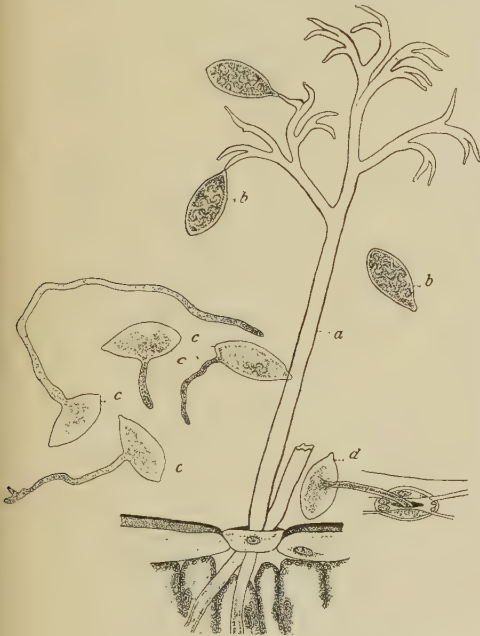


FIG. 14.—Mature conidiophore (a) with mature conidia, (c, c); (d) germ tube of conidium entering stomate.

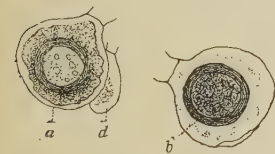


FIG. 15.—Oospores. (a) mature oospore with old antheridium, (d) still attached; (b) mature oospore still enclosed in the old wall of the oogonium.



FIG. 16.—(a) young stages of the oogonium.



FIG. 17.—Oogonium and antheridium at the time of fertilization. (a) oogonium; (b) antheridium; (c, c) septa cutting off the sexual organs from the mycelium; (d) fertilization tube.

same field the next spring. The oospores in these decaying leaves germinate under favorable conditions and infect the young onions giving rise to the disease again. Thus the life history of the parasite is completed.

CONDITIONS AFFECTING THE LIFE OF THE PARASITE.

Having discussed the different stages in the life history of the fungus, let us now examine the external conditions, which affect the parasite during these different periods. Weather conditions are perhaps the most important in determining the extent and severity

of the disease. The general opinion of observers seems to be, that warm, damp weather with continual rains or heavy dews is the most favorable to the fungus. Observations during the past season seem to confirm this opinion in most respects. During the spring and early summer of 1903 there was a long severe drought. Then followed for the remainder of the onion season much moist rainy weather. Shortly after the rains and heavy dews set in, the blight began to appear in the onion fields throughout this part of the State, indicating that moisture was one of the prime requisites for the development and spread of the fungus. It was noted that the blight occurred periodically during the season. This agreed exactly with the periodical occurrence of damp rainy weather. Professor Rowlee observed that the most serious outbreak in the onion fields about Fulton occurred during the heavy fogs to which that section is much subject. He states that this has been repeatedly observed by onion growers in that region. Potato blight (*Phytophthora infestans* De Bary) he also observed to be periodic, due to the same cause. Apparently temperature does not affect the spread of the fungus to such an extent as observers heretofore have intimated. Professor Rowlee reports that the disease was worst during the coolest weather of the latter part of August and the first days of September, and my observations confirm this. The most abundant germination of conidia was observed on onion leaves during the coolest days of the season. It has long been observed that sun and wind are unfavorable to the fungus. While at Bonney & Ware's there were two heavy rains followed immediately by hot sun and a strong breeze, which dried the onion leaves in a very short time. Although there were several infected spots in the field the sudden removal of the moisture seemed to prevent the spread of the disease and the infected patches did not increase much in area.

Another important factor is the location of the onion field. Onions on low lands with *poor drainage* are almost sure to suffer. The constant evaporation going on from such lands gives a sufficient humidity to the air except in very dry weather, to permit the growth and spread of the fungus. The growth of the tops is usually more abundant on such lands, thus allowing less circulation of the air and consequently a slower removal of moisture. Muck lands are, of course, most liable to this trouble. Moreover most of these muck lands are low lying, *i. e.*, they are surrounded by rather high hills, which shut off the winds to a considerable extent. The moisture due to heavy dews, fogs or rains, is not rapidly removed and the fungus finds here the most favorable conditions for growth. Often portions of the swamp not under cultivation are covered with trees and shrubs, thus forming a very efficient barrier to the wind. The more exposed the onion field the less danger there is of blight. It was found that the onions in these muck lands were generally planted in small patches and separated by open ditches. In most cases the banks of these ditches were grown up with tall weeds which acted as barriers to the wind. It was often observed that the blight was much worse in the onions next to these weedy barriers. Away from the ditch where the wind could get at the onions the blight was less severe.

The onions should be kept clean of weeds as they prevent free circulation of the air. On rich muck lands there is apt to be a heavy succulent growth of tops. These are easily broken over by hard rain storms and go down. This not only prevents the evaporation of moisture but weakens the tops, making them more susceptible to the attacks of the parasite. Some splendid examples of these "down spots" were observed in the field of Bonney & Ware. (See Plate I.) In this field the blight seemed to be confined almost entirely to these spots.

DISSEMINATION AND PERPETUATION OF THE FUNGUS.

The conidia or spores, as they are called, are the means by which the fungus spreads from plant to plant. These spores being so very small and light are easily carried to a considerable distance by the slightest breeze. The great numbers produced insure a very thorough distribution of the disease over the immediate neighborhood of the affected

plants. Mr. Shipley (1887) estimated that there are 70,000 stomates to every square inch of an onion leaf. In badly affected leaves he found that from at least one in every ten of these stomates a conidiophore protruded, sometimes two or three from a single stomate. Each conidiophore bears about 20 conidia, making 140,000 conidia to each square inch. This will give some idea of the vast number produced on a single diseased leaf.

These spores, as already observed, are very short-lived, much shorter lived, I believe, than has been generally supposed. Shipley (1887) stated that if the conidia dried up they would retain their germinating power only a day or two, but if the weather was favorable and there was plenty of moisture they would germinate after several weeks. Other observations, together with mine, do not seem to agree with this. Jones (1897) found, that the time necessary for bringing affected onions from the field to the laboratory, was sufficient for the loss of germinating power of the conidia. He kept the onions in a moist chamber over night and succeeded in growing a new crop of conidia which germinated readily the next morning.

I obtained germination of spores on two occasions. The first time at the home of Mr. Howard on our trip to Fulton. There the onion field was but a short distance from the house. The onions were brought home during a drizzling rain while the conidia were forming rapidly. Drop cultures in fresh rain water were at once prepared. These showed spores already germinated, though many germinated after the cultures were made. The second successful germination was of conidia obtained from diseased onions brought in from the Experiment Station Garden, only a few steps from the laboratory. This too, was on a cool rainy morning and fresh conidia were then being constantly formed, as was shown by the numerous stages of development of conidiophores and conidia, observed at that time. So abundant was the germination of these spores that almost every section from affected leaves showed germinating spores with germ tube entering stomata (Fig. 14d). From observations, I am inclined to believe that the germinating power of the conidia is not retained for more than an hour or so under the most favorable conditions and the drying out of the spore to any considerable extent seems to be fatal. This limited vitality period is made up for by the new crops of conidia, which under the proper conditions, are being constantly produced. The mycelium, as already shown, branches profusely throughout the intercellular spaces. As it spreads from the infection center new conidiophores are being constantly sent up through the stomates toward the border of the infected area. The warm sun and drying wind of the day may check their formation for the time but the mycelium within, unaffected by these external conditions, pushes out into the surrounding healthy tissue, sends its haustoria into new cells, and thus gets a good food supply which will be readily available. As soon as the dews or fogs set in, conditions become suitable and conidiophores in great abundance are sent forth from this internal mycelium through the numerous stomates of the recently infected tissue. Thus it will be seen that at each favorable opportunity, a new zone of conidia-bearing surface is added to the infected area. Very often these concentric rings or zones may be very clearly perceived by the difference in coloration from the center to the outside of the infected area. The tissues at the center, being first attacked, lost their green color soonest and appear yellowish. The different shades of green and yellow from center to margin are often quite abrupt and marked.

The great rapidity with which the disease will spread throughout a field leaving death and destruction behind is, to the grower, perhaps the most extraordinary feature of the blight. One grower whom I visited told me that his onions had no disease, but were looking fine, in fact, he had not had better prospects for a crop of onions in years. He had visited the field just a few days before. However, I asked if I might see the fields. He very courteously drove me over the field, some distance from the office. His surprise may be imagined when he reached the field to find those onions, which but two days ago were erect and green, now fallen over and faded. They looked as if scalding water had been thrown over them. No doubt at the time he looked them over, several days before, the

disease was already in them but to such an extent that only the practiced eye would have discovered it. Two days of foggy, rainy weather had just preceded my visit and in that short time the disease had almost ruined a large part of the onions.

From almost every grower I heard the same story; erect and healthy onions one day, the next, large areas blighted and dying. The rapidity with which the fungus is disseminated throughout a field may be better understood when we recall the enormous and almost continual production of conidia. A single infected onion, undiscernable in a field of green healthy ones, will produce enough spores in a single favorable day or night to infect a very large area. Not only the numbers of conidia produced but the rapidity with which they germinate is largely accountable for this rapid spreading. I found that conidia germinated and sent out tubes of sufficient length to reach and penetrate the stomates in from 20 to 30 minutes after removal from the conidiophores. The mycelium within the host must also grow very rapidly in order to produce so great a number of conidiophores in so short a time.

Having discussed the means by which the fungus propagates itself during the growing period of its host, we may now see by what means it is enabled to pass the winter or other periods unfavorable to its growth and development. The earlier investigators believed that this fungus wintered as mycelium in the bulbs of the onion, and produced conidia again when the host was planted the following year. Although it is known that most of the *Peronospora* form oospores or resting spores, as they are sometimes called, they were apparently not observed in the case of this species until in very recent years. Trelease (1884) and Dudley (1889) both believed that the mycelium passed the winter in bulbs of affected onions. The fact that it often appears among onions grown directly from the seed, on lands not previously planted to onions, caused this opinion to be questioned. Shipley (1887) described and figured the oospores in onion leaves from Bermuda and concluded that by means of these the fungus survived unfavorable conditions. According to Jones (1895), who first reported them from this country, the oospores had before been observed in Europe. Whether they had been observed by investigators previous to the time of Shipley, I have as yet not definitely determined.

Careful examination of bulbs of badly infected onions throughout the past season showed in no case any trace of mycelium in any part of the bulb. It is possible that the mycelium may in some cases winter in this way, especially in bulbs more or less protected. It is at least not advisable to use blighted onions for sets for growing seed. The fact that onions through this section are grown, in nearly every case, directly from the seed and not from sets would seem to indicate that the disease must winter usually by means of the oospores. It is safe to say that by far the greatest number of infections are from these winter spores. This is supported by their very general and abundant production. They begin to appear in the tissues of the infected onions quite early in the season. I found them in diseased onions brought to the laboratory by Mr. Culver during the early part of July. However, only a small per cent of leaves then showed them. On the second visit to Mr. Culver's place, Aug. 11, a large number of the leaves showed the oospores. Jones (1897) believed that they were not formed to any great extent until late in the season and observations in the main confirm this. There were some instances, however, in which oospores were very plentiful in the old dead leaves killed by the earliest attacks.

These oospores, as we have seen, have a thick wall or coat and dense oily contents. This makes them very resistant to extremes of heat and cold. They are formed within the tissues of the leaf and do not escape from it. The leaves dry up and fall to the ground. Here they lie during the winter and in the spring decay, exposing the oospores within, which now germinate and infect the new crop of onions. In many cases the onion tops are left on the field and so, of course, the ground is thoroughly seeded with oospores for the following season. At Canastota growers told me that rotten bulbs, as well as tops, were thrown back on the fields. A very few growers raked and burned the tops. Just how long

these oospores will live we cannot say. Shipley (1887) estimated that they will probably retain their vitality for two or three years. Jones (1897) found that soil brought from infected fields and planted to onions the next spring in the greenhouse, caused the disease to again appear, evidently from oospores in decayed leaves in the soil. Onions grown in soil from uninfected fields were not attacked. So far as I am able to learn, the germination of the oospores has not been observed in this species.

Several fields were visited during the past season on which onions had never before been grown. Still the fungus attacked them and was doing considerable damage. One case was especially noticeable in this regard. I give it in detail, as it shows how easily soil may be infected and what great care should be exercised to prevent the contamination of uninfected fields. The field was that of Bonney & Ware of Batavia. The onions were planted on muck which had been cleared but two years. During the season of 1902 it had been planted to celery. Not an onion was grown in the swamp that season. The second season (1903) the onions were planted on three acres of the land, along the west side of the swamp, the side on which was the entrance to the field. No onions were grown within half a mile of the swamp and these not in the line of prevailing winds. The conidia could not have reached the field even if they could have survived the trip. It was evident then that the oospores must in some way have reached the swamp. So far as we could learn, wild onions which might have harbored the disease did not occur in the immediate neighborhood. After some questions, it was learned that during the season of 1902, Mr. Bonney had been interested in onions grown at E. Bethany, six miles distant, and had brought his share to his barns at Batavia in the fall of that year. Here they were cleaned and stored. The waste was thrown out in the barn-yard, through which the road to the swamp led. Several men and teams were employed during this time. It often happened that one day they hauled onions from E. Bethany and the next worked in the celery field (which was to be planted to onions the following season, 1903). The same wagons were used in the celery patch the next day. It was in the fall and the roads were more or less muddy. They passed through the barn-yard in which the waste from the onions was strewn. Mr. Bonney recalled that the blight or what he now believes to have been blight, was quite common on the onions at E. Bethany during 1902. It is very evident then that this was the source of infection. Pieces of leaves containing oospores were no doubt carried to the celery patch in the wagon boxes or on the muddy wheels, or even on the feet of the men and horses. Another thing seemed to prove that the conclusions in regard to the infection of this field were correct. The disease appeared at first entirely along the west side in the first few rows. This was just where the men, during the onion harvest, had worked with the celery on days they were not hauling onions. Farther toward the east where the celery had been banked later in the season after work on the onions had ceased, no blight occurred.

Several other cases of distribution were observed. This, however, will suffice to show how easily the disease may be transferred even for long distances to uninfected fields. I think that there is little danger of infection of fields by conidia from fields a half mile or more away; and that most cases can be traced directly to the introduction of oospores in dead tops from infected fields.

It is now very easy to see how the disease has been distributed throughout this country and even the world. Nearly every farmer in the United States grows a few onions, mostly from sets. These may harbor the oospores in dry tops that cling to the little onions. Among the seed that growers of large quantities of onions use the oospores might be distributed, not in the seed themselves to be sure, but in bits of leaves and stems from infected plants. In a large onion growing district the opportunities for infection of neighboring fields are almost endless. It is almost unnecessary to point out that the most extraordinary care should be used, especially in new or uninfected lands, to prevent the introduction of any particles of dried tops from other fields.

HISTORY OF THE DISEASE.

This disease has long been known in Europe, where it is called by growers the "Onion Mildew." That it was early a common and often observed disease is evident from the following taken from the first description of the parasite (Berkley 1841). "Very common and destructive in some years, preventing the plants, which are attacked from coming to perfection." The specific name *destructor*, which Berkley applied to the parasite, would indicate that it was even at that time a very dangerous pest. No doubt it had long existed as a parasite on wild species of onions on which it is sometimes now found. The greater number of our most troublesome fungus pests have originated in this way, becoming dangerous and destructive only under the more favorable conditions afforded by a general and widespread cultivation of their host. The blight has long been known among onion growers of France and Germany as well as in England.

In 1886 the attention of the British government was called to the prevalence and destructiveness of an onion disease in the Bermuda Islands. Mr. Arthur Shipley was at once (1886) appointed to investigate the trouble. He began the work by a preliminary trip to the Canary Islands. He found two diseases very common there, which from his remarks were very evidently the blight, caused by *Peronospora schleideniana*, and the onion smut, caused by *Urocystis cepulae*. The blight which is known there as "La Escarcha" meaning hoar frost, or as "La Ceniza," ashes, from the peculiar appearance of affected leaves is not regarded by growers as dangerous. The next year (1887) Mr. Shipley visited the Bermuda Islands. He found the disease to be the blight or onion mildew, instead of an insect disease as he had anticipated. It was decidedly less than the previous year, but still plentiful enough to cause much damage. Mr. Shipley's work was very extensive. He worked out and discussed quite fully many of the important points of the life history of the fungus. He also discussed the conditions affecting the life of the fungus and suggests several ways of combating the disease. His work is by far the most comprehensive and important that has been published up to the present time.

The early history of this onion blight in the United States is very fragmentary and indefinite. So far as I can discover, the first published reference to this disease was made in the report of the microscopist, Thos. Taylor (1872) in the Annual Report of the Department of Agriculture for that year, p. 193. Several fungi occurring on onions both saprophytic and parasitic are here figured. But both figures and descriptions are so hopelessly confused that it is not clear just what the author saw. *Peronospora schleideniana* is not figured. Spores of *Urocystis* and *Macrosporium* are shown. However, from among the tangle it is possible to unravel the fact that the blight did occur to a destructive degree throughout the onion growing regions of Massachusetts and Connecticut even at that date.

Apparently not until 1883 was the disease definitely recognized and described in this country. In that year Dr. William Trelease, (1884) then of the Wisconsin Experiment Station, observed the disease in that State, and described and figured it in the First Annual Report of that station, 1884. It was apparently at that time quite a destructive disease in the West. Several pages of the report together with five figures are devoted to this fungus. This report is by far the best and most complete discussion of the disease published in this country up to the present time. It seems not to have been again reported until 1889, when Dudley (1889) then of the Cornell University Agricultural Experiment Station, reported it as having been common though not very destructive in the vicinity of Ithaca during the previous year (1888). It was reported by other Experiment Station Botanists about the same time: Thaxter (1889) from Conn.; Jones (1890) from Vermont. Jones again reported it as a serious trouble among onions in the same State in 1895-96. He also spoke of it as reported from New York. It was again reported from Wisconsin by Goff (1893.) During the present year as has already been shown, it was very common throughout this State. It would appear then, judging from the reports of this disease, that it recurs with destruc-

tive effects at least about every five or six years; 1885-86, Wisconsin, Bermuda. 1888-89, New York, Conn., '90, Vt. 1895-97, Vt., New York, Wisconsin. 1902-03, New York.

COMMON NAME OF THE DISEASE.

As is naturally to be expected various names have been applied to the disease by growers in different parts of the world. Even at the present time in this State the disease is popularly known under several different names. Some of the names applied to it in other countries have already been referred to. In this country it is generally known among growers as blight. Often the terms smut and blight are both applied to it. Smut, however, is caused by quite a different fungus. The smut fungus is much like the smut of corn or oats. It attacks the bulbs more especially forming long blisters on the outer leaves of the bulb filled with a mass of black spores. It is more destructive than the blight but does not occur so generally. "Onion mould" and the "white blight" are other names that have been applied to onions affected with *Peronospora schleideniana*. Thaxter says it is often called "white blast." Since "blight" is the term commonly used among growers in this State we have thought it best to use this name in referring to the disease.

A SECONDARY FUNGUS—MACROSPORIUM PARASITICUM.

Growers are often concerned by the blackened appearance of the dead and dying leaves, regarding this as the cause of the trouble. It was always observed that the leaves killed or greatly weakened by *P. schleideniana* soon became black. Examinations showed this to be due to a saprophytic fungus, determined by Miyabe (1889) as *Macrosporium parasiticum* Thüm, or really only a form of *M. sarcinula*, Berk. It is nearly always found on dead and decaying leaves of onions. Wherever the *Peronospora* occurs this is sure to be found. It is a secondary fungus following the blight. Miyabe thinks he has shown that it is a facultative parasite and may cause a disease of living onions independent of the blight fungus. All the observations so far seem to show that it is simply a saprophyte. Growers need not be alarmed at its appearance on dead or dying tops. It should not be confused with the blackening of the bulbs due to onion smut (*Urocystis cepulae* Frost).

OTHER DISEASES OF ONIONS OBSERVED IN 1903.

Although it is the purpose of this paper to deal chiefly with the onion blight, it may not be out of place to refer briefly to some of the other diseases of onions met with in our travels about the State. The cause of insect diseases is naturally, more generally and better understood by the average farmer than are those caused by parasitic fungi.

The onion maggot appears to have been quite destructive during the earlier part of the season in most onion districts of the State. In the onion regions about Canastota large fields were pointed out that, according to the informant, had been practically ruined by this insect. The onions in such fields were very scattered. Often entire rows had been destroyed. Those that had survived were usually large and thrifty but as these were few the crop, of course, was very short. Thrips appeared in sufficient numbers in several places to cause considerable damage. On the farm of F. A. Booths of E. Bethany, at least half of his eighteen acres of onions were very badly affected. The leaves had a whitish color due to the killing of the green tissues by these tiny insects. This, of course, greatly reduced the vitality of the leaf and hence its efficiency as a bulb builder. As the leaves grow older many of them break or bend over at some distance back from the tip. The cavity formed in the sinus of this bend affords an excellent retreat and breeding place for these tiny pests. Here they are safe from all enemies and especially from all killing mixtures that the grower may apply. No smut was met with and from what could be learned from the growers I am inclined to believe that if it occurs in this region it is very rare. Another trouble that was often observed is what is known among growers as "white tips." The leaves begin to die at the very tips becoming white and withered. This gradually extends down the leaf from

one to two or three inches. Occasionally the entire leaf succumbs. In most cases a small portion of the tip dries up while the rest of the leaf remains green and healthy. Careful microscopical examination of many of these leaves showed no traces of any fungus. Even saprophytic forms usually so common on dead onion leaves were not present. Observations on this malady leads to the conclusion that it is due to wet weather or poor drainage. The worst cases observed were at Batavia and Fulton. The field of Bonney & Ware at Batavia was in the form of a long narrow strip running north and south. The south end was bordered by a large open ditch which drained the swamp and across the ditch were uncleared swamp lands covered with tall trees. This also extended along the east side of south end, thus effectually shutting off winds and preventing the early morning sun from reaching the onions. Rains had been frequent and heavy and this part of the patch was kept constantly moister than the rest. Here the white tips of the onions were conspicuous, nearly every leaf being affected. Toward the northern end they gradually disappeared. The more exposed and drier the onions were, the less were they troubled with the disease. At Fulton on the farm of W. B. Howard there were many of these white tips. Here lack of sufficient drainage appeared to be largely the cause. The better drained portions showed very few of the white tips. Better drainage and more exposure to sun and wind are obviously the remedy for this trouble.

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I wish to say that this bulletin is not intended as a technical discussion of the fungus, *P. schleideniana*. It is prepared primarily for the onion growers of the State and is largely the report of the field work on the disease during the past season. Several interesting points regarding the morphology, etc., of the fungus which heretofore have not been observed have been worked out and will be presented later in a technical paper.

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